A Novel Technique to Detect Epipelagic Fish and Map their Habitat

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LONG-TERM GOALS

The ultimate goal of this project is to substantially improve our understanding of the relation between ecologically important key fish species (e.g. sardine and albacore) and the physical environment by collecting synoptic measurements with improved spatial and temporal resolution of observations.

OBJECTIVES

Our partnership program is striving to develop a new method for detection of fish and synoptically mapping their environment at nested spatial and temporal scales. This new technique involves employing aerial data collection techniques (which are able to collect data at a much larger range of temporal and spatial scales than traditional methods) and coupling them with directed and coordinated ship-based observations, buoy data, and satellite-derived information. The nested array of observations are being analyzed and modeled in a GIS-based environment to provide qualitative and quantitative views of habitat- and behavioral-induced fish distribution patterns.

APPROACH

The overall objective of this work is to develop a new technique to detect epipelagic fishes and map their habitat and to test this technique in the EEZ of Oregon and Washington. The secondary objective is the analyze the array of spatial data collected to better understand the connection and affects of habitat and fish behavior on fish detection and distribution. The technique combines data from satellites, aircraft, ships, and moorings. Each platform covers a unique set of spatial and temporal scales, and each instrument has its own advantages and disadvantages. A technique combining data from multiple platforms can be much more powerful than any one alone. The techniques to be combined are:

1. Satellite AVHRR (Advanced Very High Resolution Radiometer) for sea surface temperature maps.

2. Satellite SeaWIFS (Sea-viewing Wide Field Sensor) for maps of primary productivity and sediment concentration.

3. Satellite SAR (Synthetic Aperture Radar) to identify fronts in the ocean that may be associated with salinity differences and changes in sea surface roughness and to map vessel activity.

4. Airborne radiometer for sea surface temperature along transects.

5. Airborne color radiometer for primary productivity along transects.

6. Airborne LIDAR for distribution and relative abundance of fish.

7. Airborne observers for geocoded fish distribution, relative abundance, and species identification.

8. Airborne video to record images of fish schools and individual fish, aiding in species identification.

9. Ship borne echosounder for concentrations of fish (research vessel).

10. Ship borne CTD for profiles and underway sampling of temperature, salinity, and density (research and commercial fishing vessels).

11. Ship borne net sampling of fish (research and commercial fishing vessels).

12. Acoustic moorings for temporal variability of fish concentrations.

13. GIS and geostatistical analyses for data analysis, integration and display.

Spatial and temporal resolutions vary with platform. The satellite instruments will provide a weekly to bi-weekly synoptic picture of the habitat, including things like the location and strength of upwelling zones, mesoscale jets and eddies, and the position of river plumes. However, except for SAR, these instruments are not able to see through clouds or into the interior of the ocean. The airborne radiometers can fly under clouds and will provide much higher spatial resolution in the area where the fish concentrations are being measured. The underway measurements from the ship provide more accurate measurements, but only along the ship track. The ship profiles will provide the depth structure at a limited number of positions. The combination of all of these will provide a detailed picture of the 3-dimensional habitat.

WORK COMPLETED

Two active acoustic buoys were deployed 10 and 15 miles off the Columbia River Bar, Astoria Oregon, August 9-27. These sites are known as CR10 and CR15 in the long-term NOAA Fisheries sardine surveys. The moorings were deployed with the assistance of local fishermen aboard the F/V Pacific Journey. Each 200 kHz sonar collected data every 12 seconds during the study period.

Figure 1. The F/V Pacific Journey leaving the dock to deploy instruments for this work as part of our partnership with the local fishing community.

Figure 2. Oregon State University graduate student Amanda Kaltenberg deploying a sonar buoy with the help of John of the F/V Pacific Journey.

During the buoy's deployment period, spotter pilots from the fishery included the buoy locations in their flight plans whenever possible (usually leaving or returning to the airport) and reported the presence of fish, the size of a school, and a qualitative estimate of density. Fishermen working the area also provided catch data from each location.

Figure 3. The lidar equipped airplane flying over the F/V Frosti while it was collecting acoustic and trawl data.

August 16-24, the airplane equipped with a lidar sensor flew over the 2 buoys giving us a total of 290 minutes of concomitant data from more than 100 individual passes between the acoustic and lidar instruments.

Figure 4. Sardines and other animals from the trawl samples collected by the F/V Frosti along a transect over the two acoustic buoys.

During this same time period, the F/V Frosti was conducting a series of survey transects in the area. They conducted acoustic surveys at 38 and 200 kHz and sea-truthed all results using epipelagic fish and zooplankton trawls. The Oregon State University team is working to analyze the results of the acoustic buoys, which will then be combined with the results from the lidar, fishery data, acoustics survey, sea-truthing efforts, and satellite data.

RESULTS

Preliminary analysis of the sonar buoys reveals strong diel patterns in acoustic scattering. Animals were seen much shallower at night and in more diffuse aggregations with many animals migrating right to the surface. During the day, animals were seen immediately on top of the mooring (about 1 m from the bottom) to approximately 30 meters above the bottom at both sites. Animals were more highly aggregated during the day than at night. These results suggest that lidar should be detecting more targets near the surface at night though we have yet to analyze these relationships.

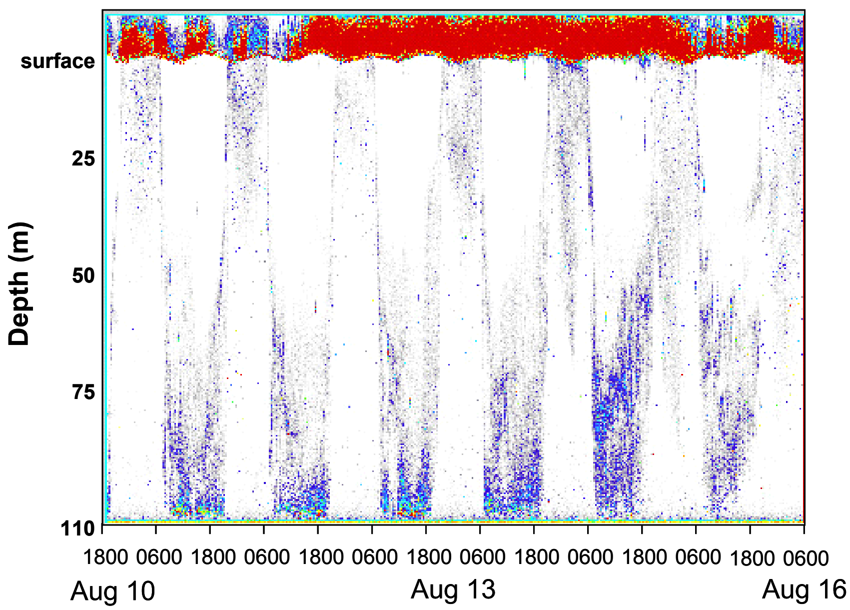

Figure 5. Six days of data from the sonar buoy placed 15 miles off the mouth of the Columbia River, Astoria Oregon (CR15). Note the strong diel patterns that were present at both sites.

IMPACT/APPLICATIONS

While in its early stages, this project will:

1. Refine Fish LIDAR data processing techniques and test the results by a comparison with echo sounder, airborne video, trawl, and quantified aerial survey visual observation data. Particular attention will be paid to taxa identification in aerial surveys using LIDAR depolarization, school morphology, and habitat clues.

2. Develop a technique to combine LIDAR, echo sounder, and sampling data to produce a species-specific measure of fish distribution. The first step will be to develop a technique to combine the data into a consistent index of abundance. We will then try to develop an accurate number density estimate.

3. Develop a technique to design the most accurate fish survey for a fixed cost. This will use adaptive sampling strategies where a low-cost LIDAR survey directs an echo sounder survey to the most productive regions within the habitat. The echo sounder survey, in turn, is used to design trawl placement to get the maximum amount of information.

4. Develop GIS-based techniques to quantitatively relate the distribution of epipelagic fishes to their habitat.

RELATED PROJECTS

The comparison of lidar and acoustic sampling techniques for assessing biology in this work is strongly related to the collaboration between Benoit-Bird and Concannon and Prentice (NAVAIR). Concannon and Prentice are funded through ONR under the LOCO DRI and Benoit-Bird through the YIP program. This project seeks to compare airborne lidar and ship and moored acoustics, focusing primarily on fish as targets while the LOCO project compares ship based lidar with ship and moored acoustics primarily focusing on plankton as targets.